

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 39

TROUBLESHOOTING EXPERIMENTS III



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Experiment Lesson 39

INTRODUCTION

This experiment lesson is designed to give you some practical experience in troubleshooting the second detector, i-f amplifier, and AVC circuits. In the audio amplifier section of the receiver, the normal signal voltages and the d-c operating voltages can be measured with the multimeter. The normal signal voltages present in the i-f section cannot be measured with the multimeter because they are too small and too high in frequency. Therefore, locating the point in the circuit where the signal disappears or becomes very weak must be done by other methods. A number of such techniques will be described in this lesson. Some of them are even more valuable in the troubleshooting of television receivers, where many more amplifier stages are present. A complete schematic diagram of the receiver is given in Fig. 39-1, and the portion of the receiver discussed in this experiment is given in Fig. 39-2.

EXPERIMENT 39-1

To learn the normal resistances and d-c operating voltages in the second detector, i-f amplifier, and AVC sections of a superheterodyne receiver.

Procedure.

Step 1. Turn the receiver off. Measure the following resistances, using the proper ohmmeter range.

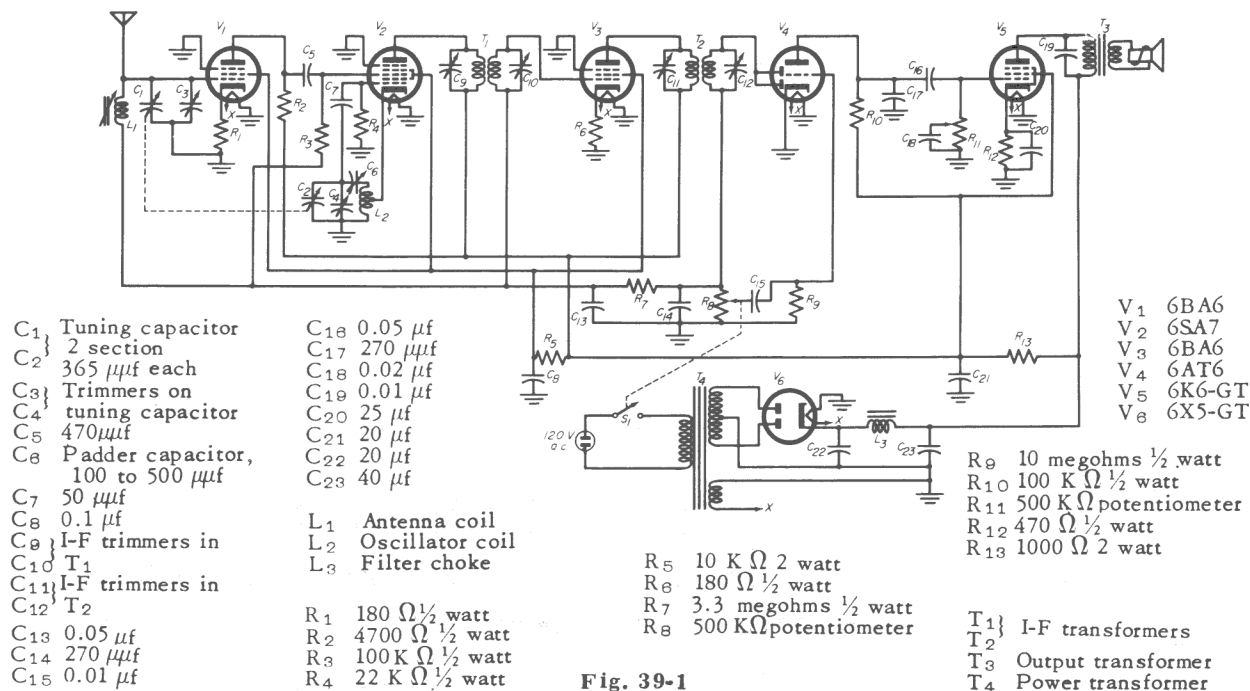
Diode detector plate to high side of volume control _____

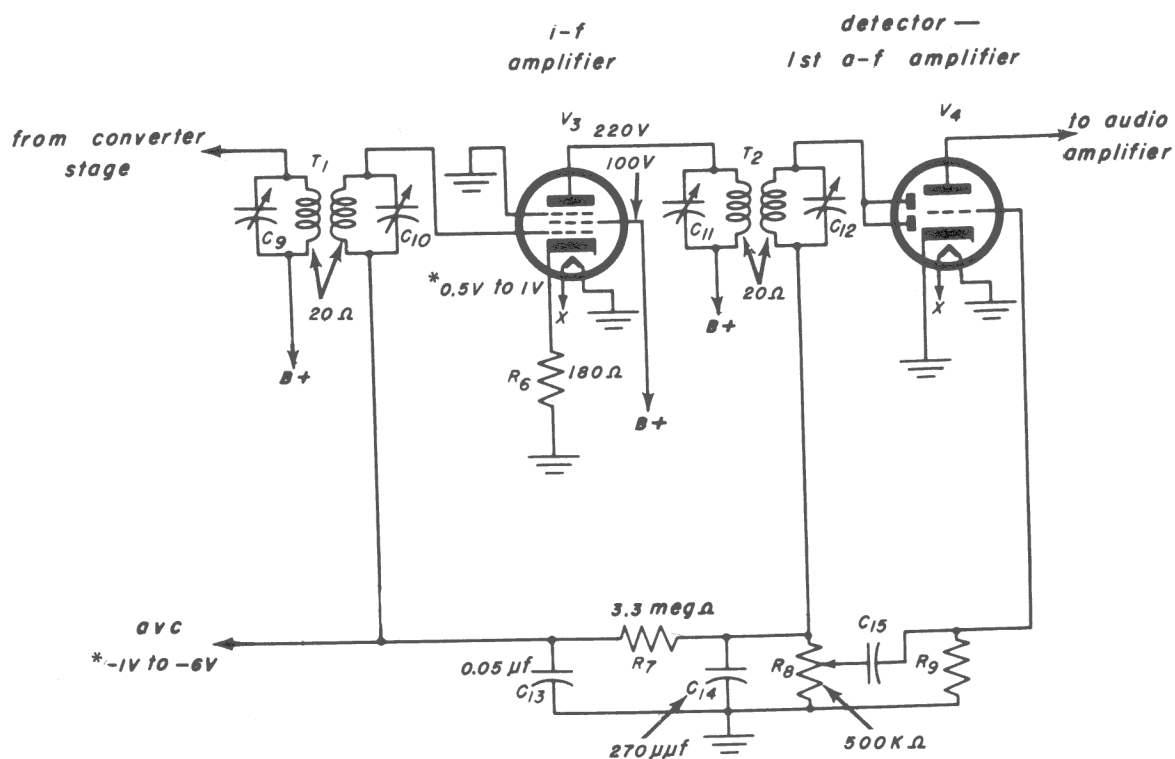
High side of the volume control to chassis _____

Diode detector plate to chassis _____

Plate of i-f tube to B+ terminal _____

Plate of i-f tube to chassis _____





* depending on signal

Fig. 39-2

Screen of i-f tube to chassis _____

Cathode of i-f tube to chassis _____

Control grid of i-f tube to chassis _____

Plate of i-f tube to detector plate _____

I-F grid to AVC terminal _____

Converter plate to B+ terminal _____

Converter plate to i-f grid _____

AVC terminal to chassis _____

Step 2. Plug in the receiver power cord, turn on the receiver, and allow the tubes to warm up.

Step 3. Measure and record the d-c voltages called for below, taking care to set up the meter properly for each measurement.

High side of volume
control and chassis*

volts d.c.

AVC terminal and chassis*

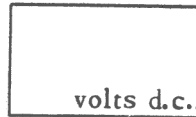
volts d.c.

Plate of i-f tube and chassis

volts d.c.

* Note the effect of tuning the receiver on this voltage.

Screen of i-f tube
and chassis



Cathode of i-f tube
and chassis



Discussion. These resistance readings show the resistance of each winding of the intermediate-frequency transformer to be about 20 ohms. Other resistance readings can be readily obtained from the component values shown in Fig. 39-2.

Air-core i-f transformers of this type usually have d-c resistances varying from about 25 to 40 ohms. The newer high-gain powdered iron i-f transformers do not need as many turns to obtain the same inductance and their d-c resistances run from about 5 to 20 ohms.

A zero resistance reading, or very low resistance reading, may indicate that the trimmer capacitor is shorted. This rarely happens, and it is more probable that the terminals of the transformer winding are shorted together due to bent terminals, excess solder, loose wires, etc. These readings also show that the resistance between the primary and secondary windings of an i-f transformer should be very high. In fact, this resistance should be infinite but when these components are wired into the circuit, a resistance of 1/2 megohm or more may be measured between them through the power-supply resistance. The other resistance readings called for serve to check the continuity of the volume control, the connection between the volume control and the diode detector, and the other components in this circuit.

The d-c voltage measurements obtained on this i-f amplifier are shown in Fig. 39-2. They are typical of most a-c receivers. The voltage measured at the high side of the volume control is due to the presence of rectified signal. This voltage, which will vary from about -0.5 volt with no signal input to about -6 volts on strong signals, is a very important servicing indication. The presence of this voltage in the correct amount

indicates that the proper signal is reaching the detector diode. When troubleshooting a dead receiver, this measurement quickly tells whether the point at which the signal is stopped is before or after the second detector.

On the other hand, if the rectified signal voltage across the diode load is too high, a different type of trouble is indicated. Voltages much higher than -6 volts indicate that the receiver is oscillating. When due to oscillation, this high voltage will remain even when the receiver is tuned off station. In this experiment lesson, a defect that causes oscillation will be introduced, and you will be able to observe this condition.

EXPERIMENT 39-2

To learn the dynamic checks that will indicate whether or not the detector circuit is operating properly.

Procedure.

Step 1. Turn on the receiver and allow the tubes to warm up. Tune in a broadcast station and measure the negative d-c voltage at the high side of the volume control. Tune the variable capacitor throughout its range, and note the variation in voltage produced.

Step 2. Turn on the signal generator and allow it to warm up.

Step 3. Set the volume control to its maximum position.

Step 4. Touch the tip of a screwdriver to the diode plate (pin 5 of the 6AT6 tube), and touch your finger to the metal shaft of the screwdriver. What is heard in the loudspeaker? What does this test tell you about the continuity of the diode-detector load circuit? Is it safe to conclude that the detector circuit itself is functioning properly on the basis of this test?

Step 5. Set up the signal generator to provide an audio-modulated r-f signal at 455 kc.

Step 6. Connect the signal generator hot

lead to the plate (pin 5) of the i-f amplifier tube.

Step 7. Adjust the volume control to maximum. What is heard in the loudspeaker? Does this test tell you that the detector circuit is functioning properly?

Discussion. As already described previously, the rectified signal voltage across the second-detector load resistor is an indication that the i-f signal is reaching the detector, and that the detector is operating properly. In this receiver, the volume control also serves as the detector load resistor. However, this test applies even when a separate fixed resistor is used as a diode load. In receivers in which this is the case, the volume control is usually connected to the diode load through a d-c blocking capacitor. No d-c voltage will be found across the volume control even if the detector is operating properly. Thus, you should check the circuit to find the load resistor before using this test. The load resistor can be easily found by starting at the black lead of the second i-f transformer, and tracing the d-c circuit from that point to ground. The resistor (resistors) that you have to pass through to return to ground constitutes the diode load.

Touching a hand-held screwdriver tip to the diode plate puts a 60-cycle a-c voltage on the plate. If the circuit is continuous, as shown in Fig. 39-3, this signal passes through the i-f transformer to the volume control and on to the 6AT6 grid, where it is amplified and sent through the audio amplifier to the loudspeaker. Thus, this 60-cycle hum heard in the loudspeaker tells that the diode load circuit is continuous. It doesn't however, test the detector circuit, whose

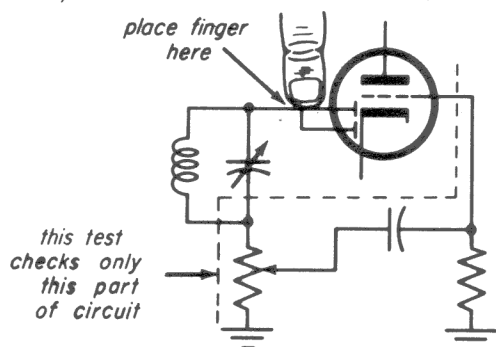


Fig. 39-3

function is to produce an audio signal from a modulated r-f signal. A defective detector tube, for example, will not be revealed by this test.

The detector circuit is completely tested by applying a modulated 455-kc signal to the detector plate, through the i-f amplifier. Although this can be done with the signal generator, you have built, many other generators may not have sufficient output to produce an audible signal without additional amplification. The generator to be used should always be tested on a receiver known to be good to learn the individual generator characteristics. If the generator does not have sufficient output, the i-f tube and the detector will have to be tested together.

EXPERIMENT 39-3

To learn the dynamic checks which will indicate whether or not the i-f amplifier is operating properly.

Procedure.

Step 1. Remove the converter tube so that no signal enters the i-f amplifier.

Step 2. Touch the tip of a screwdriver to the grid of the i-f amplifier. Try this with and without your finger making contact with the metal shaft of the screwdriver. What is heard in the loudspeaker? This clicking sound is good evidence that the i-f tube itself is amplifying. Does it tell you that the i-f transformers are tuned to the correct frequency?

Step 3. Check to see that the signal generator is set up to deliver an audio modulated r-f signal at 455 kc.

Step 4. Connect the signal generator to the plate of the i-f tube and chassis. Adjust the clip leads carefully so that they do not short to themselves or to other pins. With the r-f output control at maximum, note and record how far the volume control of the signal generator must be increased to obtain a barely audible output signal.

Step 5. Connect the signal generator to the grid of the i-f amplifier tube and chassis.

Step 6. With the r-f output control of the signal generator set for maximum output, readjust the volume control to give a barely audible signal. Judging from the two positions of the volume control, what would you say about the amplification of the i-f stage?

Discussion. Touching the tip of a screwdriver to the grid of the i-f amplifier produces a surge of voltage that is amplified by the i-f tube and reproduced as a click in the loudspeaker. Because the grid and plate circuits of the i-f amplifier are tuned to 455 kc, this stage will not amplify efficiently at 60 cycles. Thus, no hum is produced by putting your finger on this grid.

The procedure given above provides a rough way of determining, with sufficient accuracy for servicing purposes, how much the i-f tube is amplifying. When the signal generator is applied to the plate of the i-f tube, the volume control must be set near maximum in order to obtain a barely audible signal. When the signal generator is applied to the grid of the i-f tube, a barely audible signal will be obtained with the volume control near its minimum position. Thus, the difference between the two settings of the volume control gives a rough indication of the gain in the i-f tube.

EXPERIMENT 39-4

Troubleshooting in the second detector stage.

Procedure.

Step 1. To simulate an open volume control, disconnect at terminal 1 of the volume control the wire that connects this terminal to the chassis.

Step 2. Turn on the receiver and allow the tubes to warm up.

Step 3. Tune in several stations and listen carefully to the sound in the loudspeaker. Listen to voice as well as music. Is the sound clear or distorted? Tune to a quiet spot on dial where no stations are received. Is there a hum in the loudspeaker?

Step 4. Vary the volume control back and forth and note its effect. Is the volume control able to control the loudness of the receiver output in a normal manner?

Step 5. Turn off the receiver and reconnect the ground wire. Disconnect at terminal 3 of the potentiometer the wire from TS-C. What circuit does this open?

Step 6. Turn on the receiver and allow the tubes to warm up. Set the volume control to its maximum position. Is any sound heard in the loudspeaker?

Step 7. Perform the dynamic checks for the detector stage given in the previous experiment. How do the indications compare with the normal indications obtained when there is no trouble in the receiver?

Step 8. Turn off the receiver and reconnect the wire to terminal 3 of the potentiometer.

Discussion. Contrary to what might be expected, opening the diode load (in this case the volume control) near the ground end does not cause a dead receiver, but results in rather loud distorted sound whose loudness cannot be varied by the control. The case of the volume control has considerable capacity to the chassis, as shown in Fig. 39-4. At the intermediate frequency, enough signal feeds through this small capacity to produce almost normal volume. This small capacitance, however, is almost an open circuit for 60 cycles. Thus, relatively high 60-cycle a-c voltages can build up in this circuit to produce considerable hum and distortion. Because the volume control is not grounded, the voltage-divider action does not take place; maximum volume is obtained at almost all positions of the control.

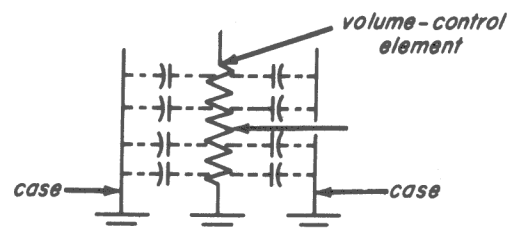


Fig. 39-4

When the high side of the diode load circuit is opened, no sound is produced in the loudspeaker. This open circuit is revealed by the dynamic test described in Step 4 of Experiment 39-2. No hum is heard in the loudspeaker when the finger is touched to the diode plate indicating an open circuit somewhere between the diode plate and volume control.

In most present day superheterodyne broadcast receivers, the diode detector is in the same envelope as the first audio-amplifier tube and uses the same cathode as the first audio amplifier triode. A defect in this tube that will affect only the detector portion and not the audio amplifier portion, while not impossible, is extremely rare. Even when a separate detector tube is used, it operates with relatively low voltages and draws very small currents. Except for filament burnouts, troubles with this tube are rare. An open filament can be readily seen, since most modern tubes of this type are glass tubes.

EXPERIMENT 39-5

Troubleshooting in the AVC circuit.

Procedure.

Step 1. Turn on the receiver and allow the tubes to warm up. Set the volume control for normal volume on a relatively weak station. Tune over the entire broadcast band and note that though stronger stations may come in louder, no station comes in so loud as to come blasting out of the loudspeaker.

Step 2. Turn off the receiver and disconnect one lead of 3.3-megohm AVC resistor to simulate an open AVC resistor. Turn on the receiver and allow the tubes to warm up. Set the volume control for normal volume on a relatively weak station. Then tune over the broadcast band and note that strong stations now come in very loud, in some cases loud enough to blast out of the loudspeaker.

Step 3. Turn off the receiver, and reconnect the 3.3-megohm resistor.

Step 4. To simulate a shorted AVC filter capacitor, ground lug 1 of TS-C with your clip lead.

Step 5. Turn on the receiver and allow the tubes to warm up.

Step 6. Set the volume control to mid-position, tune through the broadcast band and note the effect.

Step 7. Measure the AVC bias at lug 3 of TS-J. How does this differ from the normal indication?

Step 8. Measure the d-c voltage across the diode load resistor (volume control). Is the voltage much higher than normal? What does this abnormally high voltage indicate.

Step 9. Measure the d-c voltage across the 3.3-megohm AVC resistor. Should there be any voltage drop across this resistor normally? Is there a voltage drop now? What does this indicate?

Step 10. Turn off the receiver and remove the clip lead.

Step 11. To simulate a leaky AVC capacitor, connect a 47 k-ohm resistor from lug 1 of TS-C to any convenient chassis terminal.

Step 12. Turn on the receiver and allow the tubes to warm up.

Step 13. Set the volume control to mid position, tune through the broadcast band, and note the effect.

Step 14. Measure the AVC bias at lug 3 of TS-J. How does this differ from the normal indication?

Step 15. Measure the d-c voltage across the diode-load resistor (volume control). Is the voltage much higher than normal?

Step 16. Measure the d-c voltage across the 3.3-megohm AVC resistor. Should there be any voltage drop across the resistor normally? Is there a voltage drop now? What does this indicate?

Step 17. Turn off the receiver and remove the 47 k-ohm resistor.

Step 18. To simulate an open AVC capacitor disconnect the $0.05\text{-}\mu\text{f}$ capacitor at lug 3 of TS-J.

Step 19. Turn on the receiver and allow the tubes to warm up.

Step 20. Set the volume control to mid-position, tune through the broadcast band, and note the effect.

Step 21. Measure the AVC bias at lug 3 of TS-J. How does this differ from the normal indication?

Step 22. Measure the d-c voltage across the diode load resistor (volume control). Is the voltage much higher than normal? What does this abnormally high voltage indicate?

Step 23. Turn off the receiver and reconnect the capacitor.

Discussion. An open AVC resistor may cause a very considerable change in volume when tuning from weak to strong stations. This occurs because no AVC voltage is being fed back to the r-f and i-f tubes to control their gain in proportion to the strength of the incoming signal. In some receivers, an open AVC resistor may make the receiver inoperative due to blocking of the tubes because the grid return is open.

A shorted AVC filter capacitor removes the AVC bias, allowing the r-f and i-f tubes to operate at maximum gain. The results may vary in different receivers. In this receiver oscillation takes place due to the high gain of the amplifiers. There is always some feedback present in almost all circuits, either through the tube or wiring capacitances. When the amplifier is operating with normal gain, the amount of signal fed back in this way is too small to sustain oscillations. However, when the AVC line is shorted, the bias is zero. The amplifiers operate at higher than normal gain and the slightest amount of feedback may cause oscillation. The oscillation shows up as squeals as the tuning capacitor is tuned over the broadcast band. The

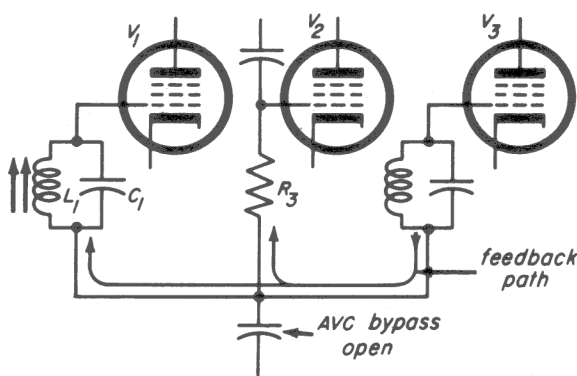


Fig. 39-5

oscillating condition is also shown by the higher than normal voltage across the second detector load resistor.

A similar effect is caused by a leaky capacitor. The exact symptoms depend upon the amount of leakage. Both of these defects cause a voltage drop across the AVC resistor. In a properly functioning receiver there is never any voltage drop across the AVC resistor. This telltale indication points to some leakage path which is allowing current to flow in the AVC line.

Although an open AVC filter capacitor does not remove the AVC bias from the control tubes it also produces a similar effect. This capacitor normally shorts out all r-f signals or i-f signals appearing on the AVC line. With this capacitor open, i-f signals can be fed back along the AVC line as shown in Fig. 39-5 from the output of the i-f amplifier to the input of the r-f amplifier. This feedback produces oscillations over the entire broadcast band.

EXPERIMENT 39-6

Troubleshooting in the i-f amplifier.

Procedure.

Step 1. To simulate a defective tube, remove the i-f amplifier tube.

Step 2. Turn on the receiver and allow the tubes to warm up.

Step 3. Measure the plate, screen, and cathode voltages and compare them with the

normal voltages measured in Experiment 39-1. What does the absence of any voltage drop across the cathode resistor indicate?

Step 4. Touch the tip of a screwdriver to the grid of the i-f amplifier tube. Is anything heard in the loudspeaker? How does this differ from the normal indication?

Step 5. Cover the leads of a 270- $\mu\mu\text{f}$ capacitor completely with spaghetti, leaving only $\frac{1}{4}$ -inch exposed at each end.

Step 6. Turn off the receiver, and connect this capacitor from pin 1 of the 6BA6 to pin 5 of the 6BA6 i-f tube.

Step 7. Turn on the receiver and turn the volume control to its maximum volume position. After the tubes have warmed up slowly tune the tuning capacitor over the entire broadcast band. What is heard? What does this test tell you about the condition of all the receiver stages except the i-f stage? If no sound is heard from the receiver until the i-f stage is bypassed in this way, what can you conclude about the location of the trouble?

Step 8. Turn off the receiver and disconnect the capacitor.

Discussion. Troubles in the i-f amplifier are usually easy to find. Most of the time, the tube is at fault. When capacitors short, or i-f transformer windings open, considerable change in the d-c operating voltages are produced. These changes point to the trouble. Defective tubes can be quickly located by substituting good tubes or by using a tube tester. If neither a good tube nor a tube checker is available, a rough idea of the condition of the i-f tube can be obtained by bypassing the stage. As described above, this is done by connecting from plate to grid of the i-f tube with a small capacitor. If the i-f tube is defective and is stopping the signal from passing through the receiver, normal sound will be heard when the stage is bypassed in this way. In fact, it is possible to bypass the entire i-f amplifier, including both i-f transformers. This may be done by connecting a small capacitor from the converter plate to the diode detector plate. If an inoperative receiver begins to

play when the capacitor is connected in this way, it quickly indicates that the converter, detector, and audio-amplifier sections of the receiver are functioning, and that the trouble is somewhere in the i-f amplifier.

Other more difficult to find defects can sometimes be quickly located by this useful procedure. It can often be used to advantage in the troubleshooting of television receivers.

EXPERIMENT 39-7

Locating misaligned stages in the i-f amplifier.

Procedure .

Step 1. The i-f transformers are temporarily going to be thrown out of alignment. If you mark the positions of the trimmers first, you will be able to restore them to their correct positions without having to go through the complete i-f alignment procedure. With a sharp pointed crayon, make a mark on the can opposite the slot of all the trimmer adjustment screws as shown in Fig. 39-6. Also make a mark inside the slot itself, as shown in the figure, so that you will be able to return the adjustment screw to the correct point by lining up the two marks.

Step 2. Turn both trimmer adjustment screws of i-f transformer T_1 one complete turn counterclockwise.

Step 3. Turn on the receiver and allow the tubes to warm up. Turn the volume control to maximum and tune through the broadcast band. The receiver should be pretty dead.

Step 4. Turn off the receiver again and connect the 270- $\mu\mu\text{f}$ capacitor so as to by-

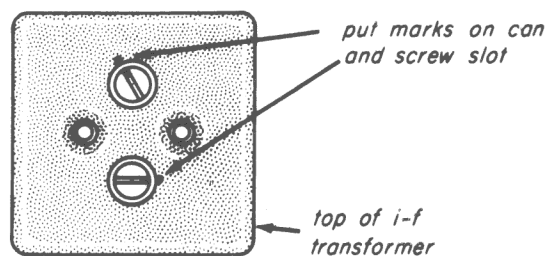


Fig. 39-6

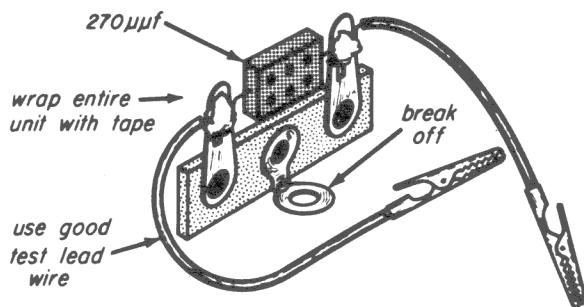


Fig. 39-7

pass the i-f transformer T_1 from the plate (pin 3) of the 6SA7 tube to the grid (pin 1) of the 6BA6 tube.

Step 5. Turn on the receiver and allow the tubes to warm up. Turn the volume control to maximum and tune through the broadcast band. Does the receiver operate now?

Step 6. Turn off the receiver and disconnect the capacitor. Return the trimmers of i-f transformer T_1 to their correct positions.

Step 7. Turn on the receiver, tune in a station, and adjust the volume control for normal volume. Carefully holding the capacitor, touch one lead to pin 3 of the 6SA7 tube and the other lead to pin 1 of the 6BA6 tube. What effect does connecting the capacitor have when the i-f transformer is properly tuned?

Step 8. Turn off the receiver, and put the capacitor aside.

Discussion. Misaligned i-f transformers can be found by applying a modulated signal from the signal generator to the converter grid. By tuning the signal generator through band A, the frequency at which maximum response is obtained can be found. If maximum response is not obtained at the proper i-f frequency, the need for realignment is indicated. However, if the receiver has been tampered with it may be so far out of alignment that no signal can be forced through. It then cannot be definitely established by using the signal generator that the trouble is in the i-f transformers. In that case, this little trick of bypassing them comes in very handy and shows definitely where the trouble is. When the capacitor is connected so as to apparently bypass a transformer that is cor-

rectly tuned it has little or no effect. A small capacitor with short clip leads attached as in Fig. 39-7 is a useful accessory.

EXPERIMENT 39-8

Further troubleshooting of the i-f amplifier.

Procedure .

Step 1. Temporarily connect a 150-ohm resistor between pins 3 and 7 of the 6BA6 i-f tube to simulate heater-cathode leakage.

Step 2. Turn on the receiver, and allow the tubes to warm up. Set the volume control to about midposition.

Step 3. Tune in several stations and note the effect on sound quality. Also note the effect between stations, and at quiet spots near each end of the dial. Is the hum present at all times or only when a signal is tuned in?

Step 4. Turn off the receiver, remove the 150-ohm resistor and put it aside. To simulate an open screen-bypass capacitor, disconnect the 0.1- μf capacitor from pin 4 of the 6SA7 tube.

Step 5. Turn on the receiver and allow the tubes to warm up. What is heard? This low frequency oscillation is called motor-boating.

Step 6. Turn off the receiver and reconnect the screen bypass capacitor. To stimulate an open suppressor grid which may be caused by incorrect wiring, loose connections, etc. disconnect pin 2 of the 6BA6 i-f tube from the center post on the tube socket.

Step 7. Turn on the receiver and allow the tubes to warm up. Turn the volume control to its maximum position and tune over the broadcast band. You should find the receiver almost dead.

Step 8. Measure the cathode voltage at pin 7 of the 6BA6 i-f tube. Is this tube con-

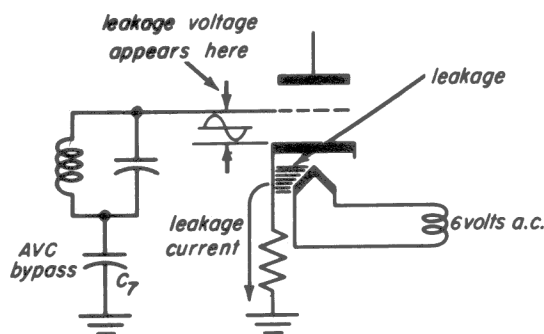


Fig. 39-8

ducting normally? What does the effect of an open suppressor grid appear to be?

Step 9. Turn off the receiver and reconnect pin 2 of the 6BA6 i-f tube to the centerpost on this tube socket.

Discussion. Leakage or shorts between the heater and the cathode of the i-f amplifier tube permit 60-cycle a-c current from the heater circuit to flow through the cathode resistor. This current sets up a 60-cycle voltage between the grid and cathode of the i-f amplifier as shown in Fig. 39-8. However, in the absence of any incoming signal this hum voltage is not heard as hum in the loud-speaker. The i-f amplifiers do not amplify at 60 cycles, and this signal is not passed through the receiver. But, when an incoming signal is tuned in, this hum voltage in the i-f amplifier modulates the r-f signal passing through the amplifier. Modulation occurs because the 60-cycle signal is strong enough to overdrive the tube. This hum is then amplified along with the signal causing hum and a distorted signal to be heard in the output. Tubes can be checked for heater to cathode leakage on the tube tester, or by substitution of good tubes. If the chassis is already out of the cabinet, then it is convenient to merely short the cathode terminal

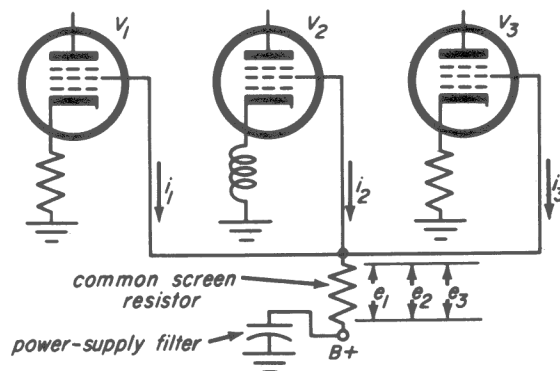


Fig. 39-9

to ground. This will tell whether or not the hum is originating in that tube.

An open screen-bypass capacitor in this particular receiver causes motorboating. The screen resistor in this set feeds more than one tube. If the screen bypass opens then screen signal currents from more than one tube will flow in this common resistor, as shown in Fig. 39-9. This allows feedback to take place between two or more tubes. Because the complete feedback circuit involves the large power supply filter capacitors, the frequency of oscillation caused by the feedback is very low, as you have heard in the experiment.

If each tube in the receiver has a separate screen resistor and screen bypass capacitor, then an open screen bypass capacitor in the i-f section will cause the i-f tube to have very low gain.

When the suppressor grid return to ground is opened, electrons pile up on this grid and cannot get off. The suppressor grid becomes sufficiently negative to block the tube and prevent plate current flow. This makes the receiver inoperative. Measurement of the cathode voltage gives a voltage that is much lower than normal, showing that the plate current through the tube is very low.